

Interpreting comparative died of wounds rates as a quality benchmark of combat casualty care

Shimul Patel, MD, Todd E. Rasmussen, MD, Shaun M. Gifford, MD, Amy N. Apodaca, MS, Brian J. Eastridge, MD, and Lorne H. Blackbourne, MD, Fort Sam Houston, Texas

BACKGROUND:	The died of wounds (DOW) rate is cited as a measure of combat casualty care effectiveness without the context of injury severity or insight into lethality of the battlefield. The objective of this study was to characterize injury severity and other factors related to variations in the DOW rate.
METHODS:	The highest monthly DOW (HDOW) and lowest monthly DOW (LDOW) rates from 2004 to 2008 were identified from analysis and casualty report databases and used to direct a search of the Joint Theater Trauma Registry. Casualties from the HDOW and LDOW were combined into cohorts, and injury data were analyzed and compared.
RESULTS:	The HDOW rates were 13.4%, 11.6%, and 12.8% (mean, 12.6%), and the LDOW rates were 1.3%, 2.0%, and 2.7% (mean, 2.0%) ($p < 0.0001$). The HDOW (n = 541) and LDOW (n = 349) groups sustained a total of 1,154 wounds. Injury Severity Score was greater in the HDOW than the LDOW group (mean [SD], 11.1 [0.53] vs. 9.4 [0.58]; $p = 0.03$) as was the percentage of patients with Injury Severity Score of more than 25 (HDOW, 12% vs. LDOW, 7.7%; $p = 0.04$). Excluding minor injuries (Abbreviated Injury Scale score of 1), there was a greater percentage of chest injuries in the HDOW compared with the LDOW group (16.5% vs. 11.2%, $p = 0.03$). Explosive mechanisms were more commonly the cause of injury in the HDOW group (58.7% vs. 49.7%; $p = 0.007$), which also had a higher percentage of Marine Corps personnel ($p = 0.02$).
CONCLUSION:	This study provides novel data demonstrating that the died of wounds rate ranges significantly throughout the course of combat. Discernible differences in injury severity, wounding patterns, and even service affiliation exist within this variation. For accuracy, the died of wounds rate should be cited only in the context of associated injury patterns, injury severity, and mechanisms of injury. Without this context, DOW should not be used as a comparative medical metric. (<i>J Trauma Acute Care Surg.</i> 2012;73: 60–63. Copyright © 2012 by Lippincott Williams & Wilkins)
LEVEL OF EVIDENCE:	Prognostic study, level III.
KEYWORDS:	Wartime injury; lethality of battlefield; military trauma.

Case fatality rates, killed in action (KIA) rates, and died of wounds (DOW) rates are commonly used as epidemiologic markers for our nation's wars. The calculations involved in these rates are regulated by intricate distinctions in numerators and denominators, which are often misquoted and misunderstood. Holcomb,¹ understanding the complex nature of these statistics, extended upon previous definitions in an attempt to clarify how they should be used. He streamlined these into measures of the lethality of the battlefield (case fatality rates), the effectiveness of point of injury care and transport systems (KIA), and the effectiveness of operational combat casualty care (DOW).¹ With these focused assessments, comparison of epidemiologic markers for different wars is possible and allows

for a more thorough understanding of medical, operational, and preparation needs.

Improvements in time to surgical assessment of injuries with the successful deployment of forward surgical capabilities, the effective use of point of injury care tactics such as combat application tourniquets^{2–4} and hemostatic dressings,⁵ and enhanced preparatory phases for deploying medical professionals, such as the Tactical Combat Casualty Care Course, Joint Forces Combat Trauma Management Course, and Emergency War Surgery Course,⁶ would suggest that care for injured soldiers has improved. Despite this enhancement in care, the overall DOW rate has increased slightly from 3.5% and 3.2% in World War II and Vietnam, respectively, to 4.8% in our current conflicts in Iraq and Afghanistan,¹ implying that the effectiveness of combat casualty care is poor.⁷

As combat casualty care continues to evolve from analysis of casualty data,^{7–12} factors other than the quality and competence of combat casualty care may be related to increased DOW rates. To date, no studies have been performed to ascertain the impact of specific operational and injury metrics on DOW rates.

This study aimed to use the DOW rates calculated by the Department of Defense and determine if, within the high and low DOW months, there are discernible differences in wounding

From the US Army Institute for Surgical Research, Brooke Army Medical Center, Fort Sam Houston, Texas.

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Address for reprints: Todd E. Rasmussen, MD, US Institute of Surgical Research, Fort Sam Houston, Texas; email: todd.rasmussen@amedd.army.mil.

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patterns and body regions injured, severity of body-region injury and Injury Severity Scores (ISSs), and mechanism of injury.

METHODS

The monthly DOW rates (%DOW = [number of died after reaching military treatment facility / (number of wounded in action – number of return to duty)] × 100),¹³ were determined from January 2004 to December 2008 and disaggregated by the Statistical Information Analytics Division, US Military Casualty Statistics. The raw numbers were from casualty reports via the Defense Link Web site and from the Directorate for Information Operations and Reports database. A high DOW (HDOW) cohort was created from the three highest yearly DOW rates. A low DOW (LDOW) cohort was created from the three lowest yearly DOW rates.

The Joint Theater Trauma Registry (JTTR) is a database of casualty medical treatment information on patients treated in a US medical treatment facility. This database is largely compiled from information obtained at role three (Combat Support Hospitals) medical treatment facilities. This database was queried for casualty information on the HDOW and LDOW cohorts. All casualties classified as KIA were excluded. Casualties who were DOW, return to duty (RTD), or requiring greater than 72 hours of care were included. Specific data collected included basic demographic information, facility patient was logged at, theater of operation injury occurred in, cause of injury, ISS, body region injured (head, 1; neck, 2; chest, 3; abdomen, 4; extremities, 5; and superficial, 6) and associated Abbreviated Injury Scale score, logged vital signs, Glasgow Coma Scale score, and final disposition status.

RESULTS

Categorical data were summarized as percentages. In order to compare injury patterns and mechanisms of injury for HDOW versus LDOW Chi-Squared tests were used. Continuous variables were tested for normality. Those that met the criteria for normality were summarized using means and standard deviations. Group comparisons between HDOW versus LDOW were analyzed using Student's t-test and ANOVA. Non-

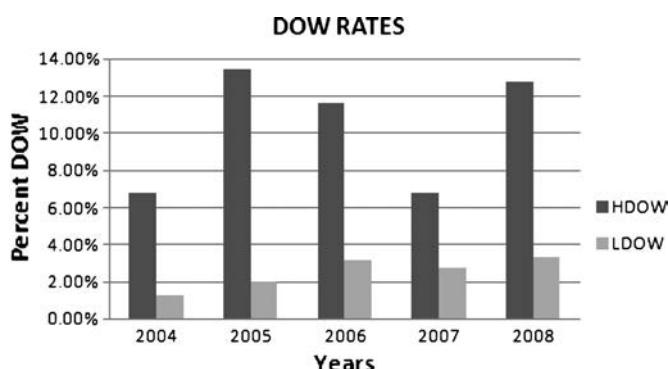


Figure 1. Highest and lowest DOW rates for each year 2004 to 2008. The HDOW cohort is composed of the high rates for 2005, 2006, and 2008. The LDOW cohort was composed of the low rates for 2004, 2005, and 2007.

TABLE 1. Physiologic Parameters for LDOW and HDOW Obtained From the JTTR

	Physiologic Parameters	
	LDOW	HDOW
Heart rate, mean (range), beats per min	92.2 (44–170)	87.3 (40–187)
Systolic blood pressure, mean (range), mm Hg	131.7 (80–197)	128 (38–204)
Oxygen saturation, mean (range), %	97.3 (74–100)	96.1 (61–100)
Temperature, mean (range), F	98.1 (92–102)	98.0 (91.6–102.4)

normally distributed continuous variables were analyzed using the Wilcoxon Test and medians with inter-quartile ranges were used to provide summary statistics. Statistical significance was set at $p < 0.05$.

As shown in Figure 1, the HDOW and LDOW cohorts were composed of months with the rates 13.4%, 11.6%, and 12.8% (mean, 12.6%) and 1.3%, 2.0%, and 2.7% (mean, 2.0%), respectively ($p < 0.0001$). JTTR query yielded a total of 890 casualties (LDOW, 349; HDOW, 541). Physiologic parameters (Table 1) and demographics (Table 2) were similar between the two groups with the exception of branch of service (15.7% Marine in HDOW vs. 9.2% in LDOW; $p = 0.02$).

HDOW cohort sustained a total of 737 body region 1 to 5 injuries (1.36 injuries per casualty) and the LDOW cohort sustained a total of 417 body region 1 to 5 injuries (1.19 injuries per casualty). Overall rates of injuries for these body regions were 31% head injuries, 23% facial injuries, 15% chest injuries, 12% abdominal injuries, and 49% extremity injuries. Excluding minor injuries (Abbreviated Injury Scale score of 1) and body region 6 injuries, HDOW had 24% head injuries, 10% facial injuries, 16% chest injuries ($p = 0.03$ each), 11% abdominal injuries, and 45% extremity injuries ($p = 0.06$ each), and LDOW had 22% head injuries, 9% facial injuries, 11% chest injuries ($p = 0.03$ each), 9% abdominal injuries, and 38% extremity injuries ($p = 0.06$ each) (Fig. 2). An additional 704 injuries were categorized as body region 6, superficial injuries (HDOW, 423 [48%] vs. LDOW, 281 [32%]). The overall mean

TABLE 2. Demographic Information for LDOW and HDOW From the JTTR

	Demographics	
	LDOW (n = 349)	HDOW (n = 541)
Sex, % (n)		
Male	98.9 (345)	98.2 (531)
Female	1.1 (4)	1.2 (10)
Age, mean, y		
Male	26.3	26.0
Female	22.8	25.7
Theater, % (n)		
OIF	90.8 (318)	91.5 (495)
OEF	8.9 (30)	8.5 (46)
Branch of service, % (n)		
Army	89.4 (312)	81.7 (442)
Air Force	0.86 (3)	1.3 (7)
Marine	9.2 (32)*	15.7 (85)*
Navy	0.6 (2)	1.3 (7)

* $p < 0.02$

OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom.

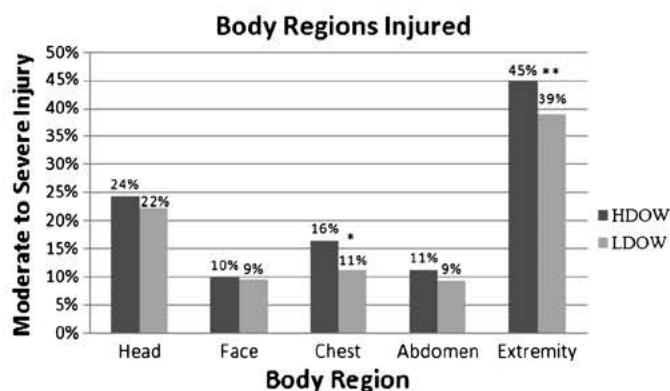


Figure 2. Percentage of body regions injured with Abbreviated Injury Scale scores of 2 to 6 in HDOW and LDOW groups when looking at body regions 1 to 5: head, face, chest, abdomen, and extremity (* $p = 0.03$, ** $p = 0.06$).

(SD) ISS in HDOW cohort was 11.1 (0.53) and in LDOW cohort was 9.4 (0.58) ($p = 0.03$). The percentage of casualties with ISS higher than 25 in HDOW was 12% versus 7.7% in LDOW ($p = 0.04$).

Overall mechanism of injury patterns demonstrated 55.2% improvised explosive device (IED) (HDOW, 58.7% vs. LDOW, 49.7%; $p = 0.007$) and 16.4% gunshot wound/firefight, and the remaining 28.4% were assault, burns, crush, fall, grenade, helicopter crash, motor vehicle accident, mines, mortars, knife, and blunt and penetrating injuries not otherwise specified (Fig. 3).

DISCUSSION

The terminology used to describe wartime casualty statistics has been confusing and calculated in a way that has made comparing past and present experiences difficult. With the efforts of Holcomb and others, a more thorough understanding with specific definitions has made comparison possible. We have shown that to further assess wartime casualty statistics, deeper evaluation focusing on injury metrics is needed to put the statistics in the appropriate context. Specifically, we have determined that HDOW rates are associated with greater raw number of casualties in HDOW cohort than in LDOW cohort, greater mean ISS, greater percentage of casualties with an ISS higher than 25, greater rate of chest injuries, and a greater percentage of injuries sustained by IED explosions.

Our findings concerning body regions injured are similar to the findings of Owens et al.¹⁴ from an analysis of casualties from October 2001 to January 2005. They determined that of their 1,556 combat casualties, 29.4% sustained head and neck injuries, 10.7% abdominal injuries, and 54.1% extremity injuries. Interestingly, the chest injury rate for their population was 5.6%, much lower than our overall mean of 15%. The DOW rate for their cohort was 3.4%, which is more consistent with previous war rates. The highest rate of torso injuries was seen in our HDOW group. Previous reports have shown that noncompressible hemorrhage continues to be a leading cause of death for combat casualties.¹⁵ Our findings suggest that higher DOW rates may be associated with a greater percentage of casualties with torso hemorrhage.

Kelly et al.¹⁵ performed an analysis of injury severity and causes of death from the beginning of the war (2003–2004) compared with those later in the war (2006) and concluded that injury severity was in fact higher in the 2006 cohort. Interestingly, they also noted that the DOW rate for what they determined to be potentially survivable injuries was higher in the 2006 cohort versus 2003 to 2004 cohort. This information, in addition to our finding that the DOW rate is higher when there are more severe injuries, lends credence to the statement that the DOW rate needs to be looked at in light of injury severity. This same study also demonstrated that the cohort with more severe injuries had a greater percentage of IED and other explosive mechanisms of injury.¹⁵

A finding that we did not expect to see was the significant difference in the service affiliation of the casualties. A likely explanation for this is that the periods that our HDOW cohort covers were times with increased intensity of fighting and movement of troops into new territories, jobs often led by Marines. This also alludes to the fact that operational tempo and the lethality of the battlefield play a part in DOW rates.

Differentiation of combat-related deaths into KIA and DOW depends on close interconnected principles. In the most simple of definitions, if casualties do not survive to the point of medical care, they are deemed KIA. With more forward deployed capabilities and the likelihood of soldiers being seen within minutes of wounding, it is not hard to imagine field medics and brothers in arms transporting all injured personnel to medical facilities, regardless of the chances for survival. In past wars with delayed transport, severely injured soldiers may not have had the same chances as they would today. This study did not look at KIA rates for the same periods. In World War II and Vietnam, of those soldiers who died, 88% were KIA and 12% were DOW compared with the current conflicts in Iraq and Afghanistan where 77% are KIA and 23% DOW.¹ Current reports have documented a decrease in KIA rates from 20% in Vietnam to 13.8% in Iraq and Afghanistan, an observation that can be explained by forward placement of medical care.

There are some limitations in this study worth mentioning aside from the ones inherent to retrospective analysis. The population that the Department of Defense uses to calculate

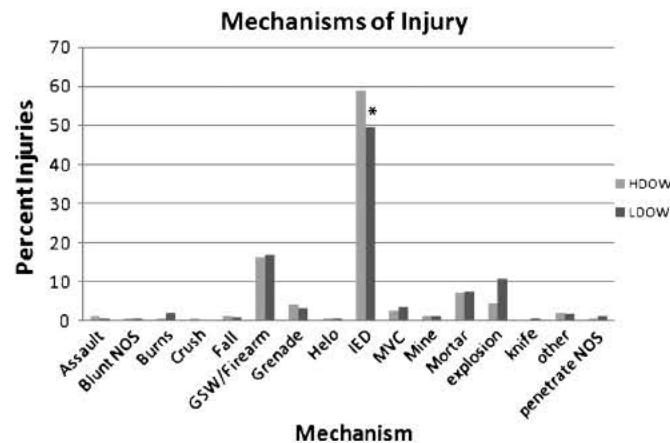


Figure 3. Detailed mechanism of injury in HDOW and LDOW groups (* $p = 0.007$).

DOW rates includes casualties seen at all levels of care from role one (the battalion aid station) to role three (the combat support hospitals). Our patient information comes from the JTTR, which is the most robust information source we have available for combat casualty medical information. As with any database, it can only capture those casualties that are seen and patient data that are documented. As such, these records correspond largely to the role three facilities in Iraq and Afghanistan. Finally, this study looks at DOW rates in Iraq and Afghanistan combined. Despite only 10% of casualties coming from Operation Enduring Freedom, it would be beneficial to look from 2008 to the present to discern differences in DOW rates between theaters and correlate with different evacuation times as well as different mechanisms of injury.

In conclusion, this study provides novel data demonstrating that the DOW rate ranges significantly throughout the course of combat. Discernible differences in injury severity, wounding patterns, and even service affiliation exist within this variation. For accuracy, the DOW rate should be cited only in the context of associated injury patterns, injury severity, and mechanisms of injury. Without this context, DOW should not be used as a comparative medical metric.

AUTHORSHIP

T.E.R, B.J.E and L.H.B conceived and designed this study. S.P. and S.M.G. performed the literature review for the projects. S.P., S.M.G. and A.N.A. performed the data collection, analysis and organization. S.P. and S.M.G. provided the original drafts of the manuscript, tables and figures. Final review and editing was performed by T.E.R, B.J.E, A.N.A. and L.H.B.

DISCLOSURE

The authors declare no conflicts of interest.

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